



## Engineering Research Report

The work covered by this report was undertaken by the BBC Research Department for the BBC and the IBA

# ARRAYS OF UHF LOG-PERIODIC AERIALS: a vertically-polarised receiving aerial for re-broadcast links

G.H. Millard, B.Sc., M.Inst.P.  
J.L. Riley, M.Sc.



ARRAYS OF UHF LOG-PERIODIC AERIALS:  
A VERTICALLY-POLARISED RECEIVING AERIAL FOR RE-BROADCAST LINKS  
G.H. Millard, B.Sc., M.Inst.P.  
J.L. Riley, M.Sc.

**Summary**

The aerial array described comprises four u.h.f. ruggedised log-periodic aerials and is suitable for vertically-polarised reception at some r.b.l. sites. The u.h.f. Bands IV and V are covered by two versions, differing in dimensions only.

The impedance match to  $50\Omega$  and the horizontal radiation pattern sidelobe level meet the specification. The average effective gain, taking into account the losses associated with the distribution transformer and interconnecting leads is about 12.5 dB.

Issued under the authority of

Research Department, Engineering Division,  
BRITISH BROADCASTING CORPORATION

September 1974

(RA-132)

Head of Research Department



**ARRAYS OF UHF LOG-PERIODIC AERIALS:  
A VERTICALLY-POLARISED RECEIVING AERIAL FOR RE-BROADCAST LINKS**

Section	Title	Page
<b>Summary</b>	.....	<b>Title Page</b>
<b>1.</b>	<b>Introduction</b> .....	<b>1</b>
<b>2.</b>	<b>Aerial design</b> .....	<b>2</b>
<b>3.</b>	<b>Mechanical arrangement</b> .....	<b>2</b>
<b>4.</b>	<b>Measured performance</b> .....	<b>3</b>
	<b>4.1. Horizontal radiation pattern</b> .....	<b>3</b>
	<b>4.2. Reflection coefficient</b> .....	<b>3</b>
	<b>4.3. Gain</b> .....	<b>4</b>
<b>5.</b>	<b>Icing conditions</b> .....	<b>4</b>
<b>6.</b>	<b>Conclusions</b> .....	<b>4</b>
<b>7.</b>	<b>References</b> .....	<b>5</b>



ARRAYS OF UHF LOG-PERIODIC AERIALS:  
A VERTICALLY-POLARISED RECEIVING AERIAL FOR RE-BROADCAST LINKS  
G.H. Millard, B.Sc., M.Inst.P.  
J.L. Riley, M.Sc.

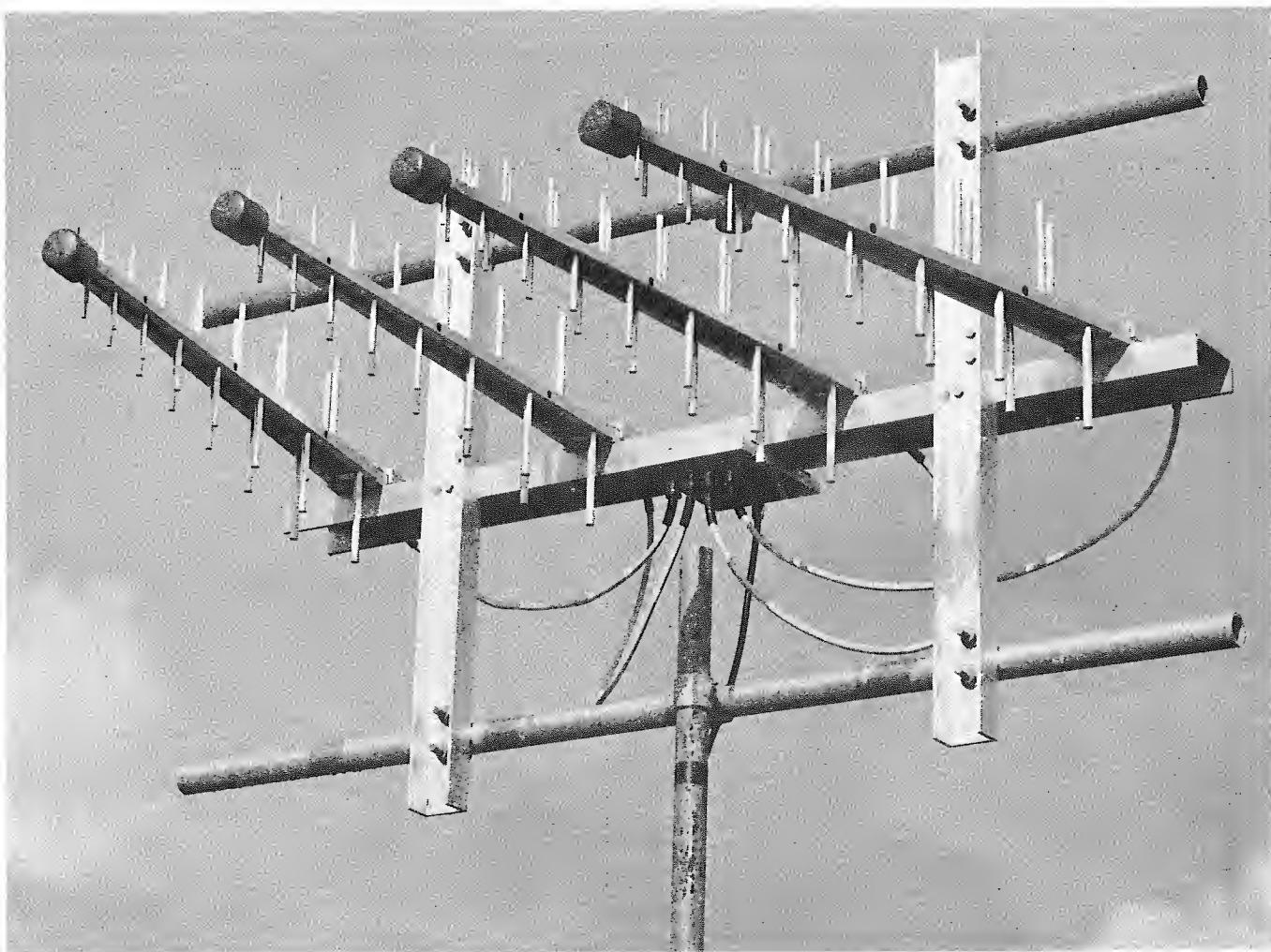
## 1. Introduction

A vertically-polarised receiving aerial for re-broadcast links (r.b.l.) has recently been developed.<sup>1</sup> It is the vertically-polarised equivalent of the horizontally-polarised 'trough' aerial currently in service. This report describes how an array of four u.h.f. ruggedised log-periodic aerials can be used for the same purpose at sites where favourable weather conditions prevail.

The main cause of signal degradation at r.b.l. sites is co-channel interference and a highly directional horizontal radiation pattern (h.r.p.) with low sidelobes is required. The templet for the h.r.p. which was assumed for the r.b.l. aerial and which was based on calculations of co-channel interference<sup>2</sup> is shown in Figs. 2 and 3.

The aerial impedance match is based on the permissible level of delayed image signal appearing at the transposer input. The delayed signal is produced by reflection of the primary signal from the imperfectly-matched transposer input and re-reflection at the aerial. The level of the delayed signal depends, therefore, on the input impedance match of the transposer and on the length and type of interconnecting feeder between it and the aerial.

The transposer input reflection loss is specified to be not less than 20 dB. Splitting filters which are normally placed between the aerial and transposer may reduce the reflection loss to 10 dB. Assuming that the feeder length will not usually be more than 40 m with a loss of typically 2.5 dB, the maximum permissible reflection coefficient of the aerial is 20%.



*Fig. 1 - The u.h.f. ruggedised log-periodic vertically-polarised array for Band IV*

## 2. Aerial design

The log-periodic aerial is a wideband aerial with very low side- and back-lobe radiation and with moderate gain. The u.h.f. ruggedised version of the aerial is a recent development<sup>3</sup> and has an input reflection coefficient of less than 12% and an effective gain of 8 dB over the u.h.f. Bands IV and V.

Four log-periodic aerials stacked in the H-plane are sufficient to achieve the specified h.r.p. beamwidth. A tapered current distribution to the aerials of 1 : 2 : 2 : 1 is used to reduce the sidelobes and satisfy the templet.<sup>4</sup>

The spacings between aerials are chosen to optimise the total aerial gain over the working bandwidth. For the log-periodic aerial the reference point from which radiation may be said to emanate is variable with frequency. This point, known as the phase-centre is, if it exists, that origin of co-ordinates about which, for a particular polarisation of the aerial, the phase of the far-field radiation remains substantially constant as the azimuthal angle is varied. At the lower end of the frequency range the phase-centre occurs towards the back of the aerial and at the upper end of the frequency range it occurs towards the front.

In the case of aerials stacked in a parallel fashion, the separation between aerials, expressed in wavelengths, would vary with frequency and the gain and the pattern bandwidth would be limited. The bandwidth can be increased by slewing the aerials towards an imaginary centre line along the direction of fire. The angle of slew is limited by the requirement for low sidelobes and by scattering effects from aerials firing at each other. The optimum angle of slew was found by experiment to be 8° between adjacent aerials.

Two versions of the log-periodic array, differing only in dimensions of separation, are required to cover the u.h.f. bands; one for Band IV and one for Band V.

## 3. Mechanical arrangement

The aerial array mounted on its support structure is shown in Fig. 1. The four log-periodic aerials are located by preset drillings and rigidly clamped to a main horizontal aluminium alloy U-channel section girder. A different main channel member is required for each version. The mechanical separation between the longest elements of the

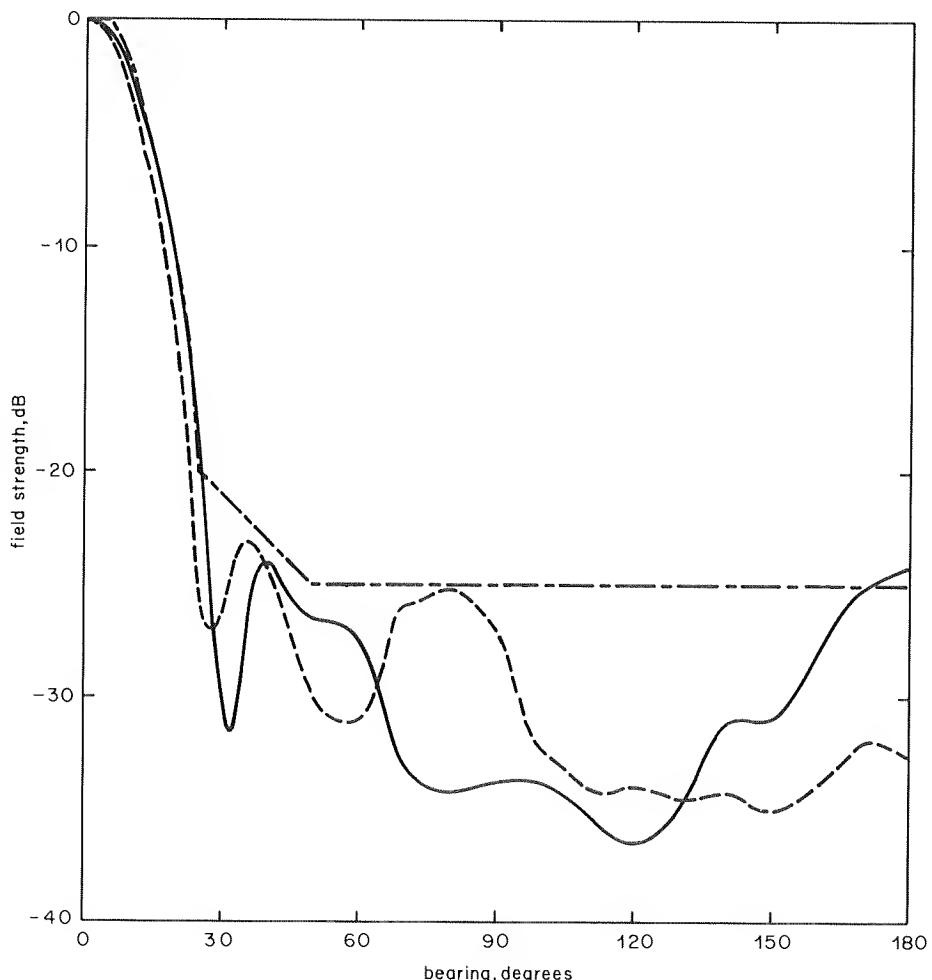
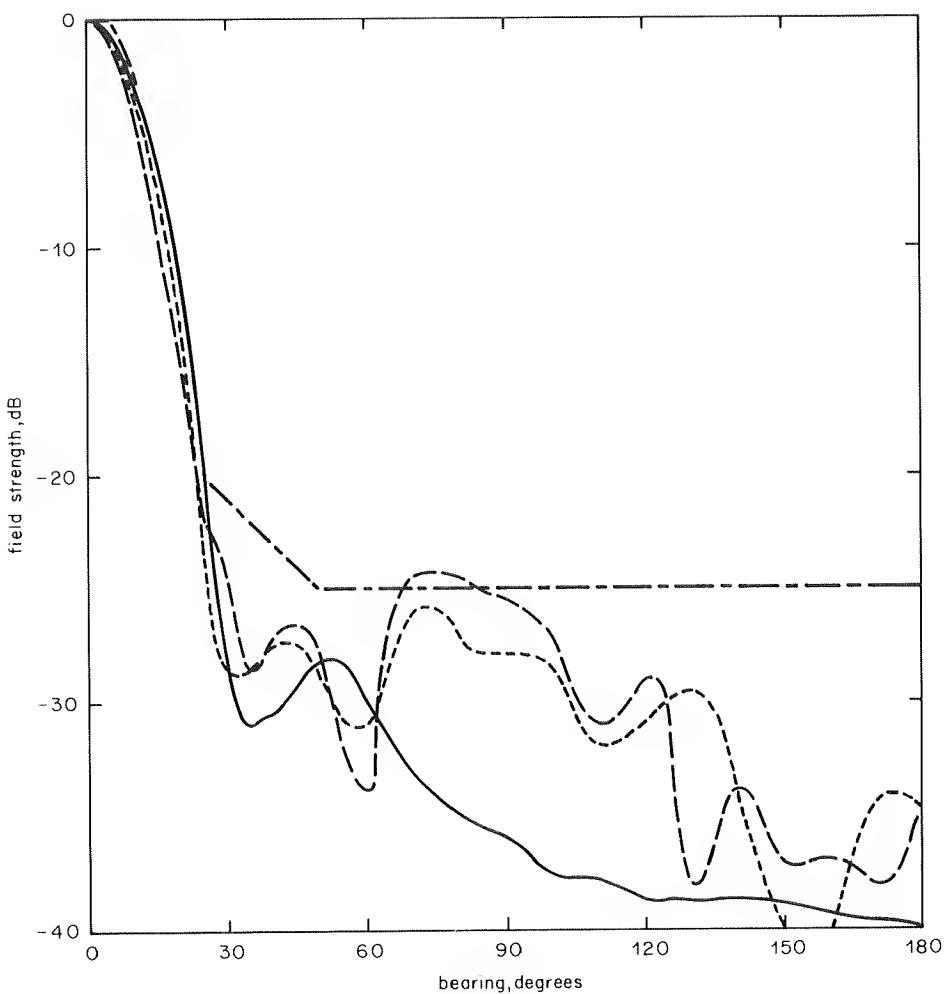


Fig. 2 - Measured horizontal radiation pattern of the log-periodic RBL array for Band IV

— 450 MHz — 600 MHz - - - - - Templet



*Fig. 3 - Measured horizontal radiation pattern of the log-periodic RBL array for Band V*

— 600 MHz ——— 700 MHz ———— 850 MHz ———— Templet

aerials is approximately 430 mm for the Band IV version and 400 mm for the Band V version.

Two further U-channel members of smaller section are bolted to the main channel so that they are vertical and spaced approximately midway between the outermost and innermost aerials. Pairs of holes are provided at the extremities of the vertical members so that U-bolts can be used to secure the complete assembly to a pair of standard scaffold poles rigidly fixed to the mast. This method of attachment is similar to that used for the existing 'trough' aerial.

The distribution transformer providing the four outputs in the ratio 1 : 2 : 2 : 1 is of printed circuit form and is sealed in an aluminium alloy tray.<sup>4</sup> It is mounted upside-down below the centre section of the main channel. The distribution leads between transformer and aerials are approximately 1 m long.

#### 4. Measured performance

##### 4.1. Horizontal radiation pattern

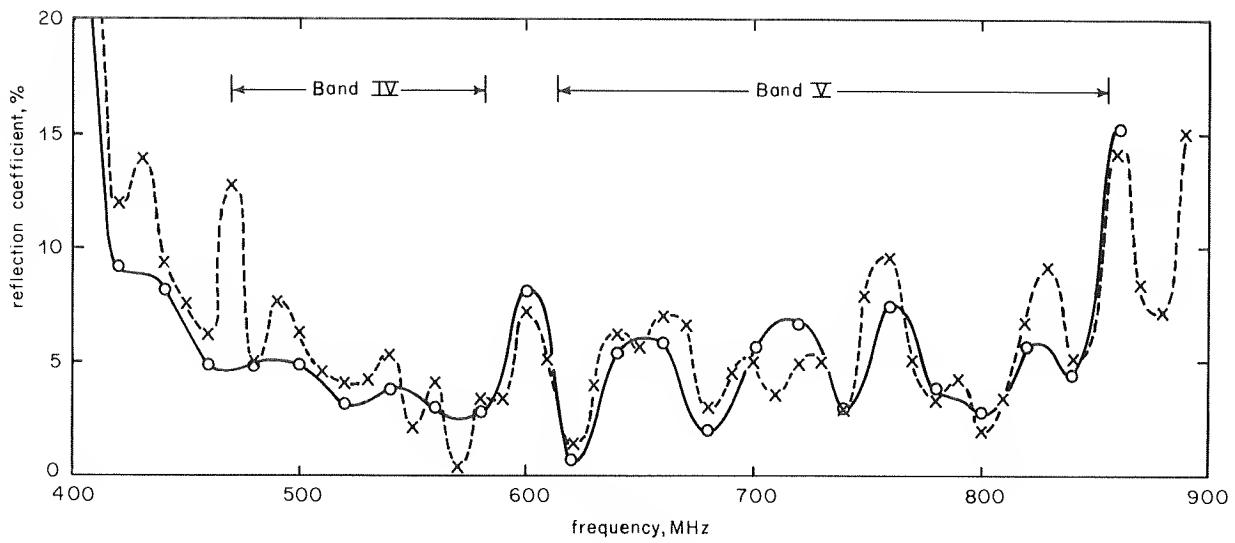
The distribution leads are of lengths chosen to pro-

duce nominally co-phased signals at each aerial input connector to within  $\pm 5^\circ$  in Band IV and  $\pm 8^\circ$  in Band V. This is necessary because the four outputs from the splitter transformer are not already co-phased. The aerials themselves exhibit a spread in phase of about  $\pm 5^\circ$ .

The h.r.p.'s shown in Figs. 2 and 3 are the r.m.s. averaged results measured at several frequencies within the respective band. In no case is there more than a minor transgression of the templet. The worst deviation occurs at the upper end of Band V where the second sidelobe level may rise up to 2 dB above the templet. There may be minor changes of pattern in the side- and back-lobe region because production spreads affect the behaviour of the individual log-periodic aerial.

##### 4.2. Reflection coefficient

The measured reflection coefficient at the input of the distribution transformer is shown in Fig. 4. In general, it is less than 8% but rises to 14% at the upper end of Band V. There is, therefore, a comfortable margin over the proposed target of 20%.



*Fig. 4 - Measured impedance match of the log-periodic RBL array for Bands IV and V*

O———○ Band IV arrangement      X-----X Band V arrangement

#### 4.3. Gain

The aerial gain, computed from the measured radiation patterns, is shown in Fig. 5. An allowance has been made for the losses associated with the distribution transformer and leads. It is interesting to compare the gain results with those of the equivalent trough aerial. These latter results are reproduced<sup>1</sup> in Fig. 5 for convenience. The log-periodic array gain is generally more nearly constant, particularly in Band IV. In the lower part of Band V the array gain is approximately 0.5 dB lower than the trough and in the upper part of Band V the array gain is approximately 0.5 dB higher than the trough.

#### 5. Icing conditions

Unlike the standard r.b.l. trough aerial, the log-periodic does not have a cover to protect it from the weather in order to keep the wind-loading area as small as possible.

Protection of the aerial is satisfactory except in conditions of severe icing.<sup>3</sup> The dielectric wedge prevents ice forming in the sensitive region immediately between the

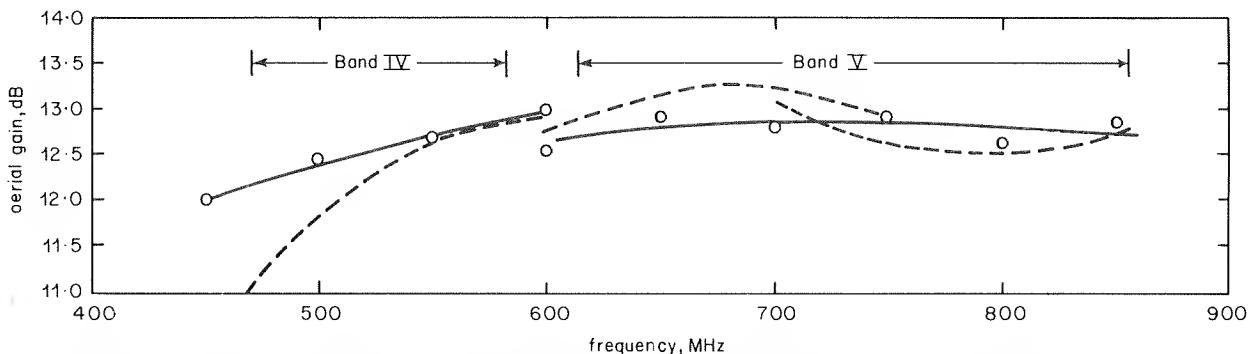
booms but does not prevent the build-up of ice across the boom. The impedance match and front-to-back ratio of the aerial could be degraded in severe icing conditions.

At present it is not known how severe the icing must be to significantly affect the aerial performance. Experience with a number of prototype aerials which have already been put into service will help to clarify the situation.

#### 6. Conclusions

An array of four ruggedised u.h.f. log-periodic aerials can be used successfully to meet the r.b.l. aerial requirement. The effective gain of the aerial is reasonably constant over the u.h.f. Bands IV and V and is on average about 12.5 dB.

The extent to which the u.h.f. log-periodic aerial is affected by ice is not known precisely at this time and this may slightly reduce the number of sites which are suitable for the r.b.l. log-periodic array.



*Fig. 5 - Computed aerial gains of the log-periodic RBL array and the vertically-polarised trough aerial for Bands IV and V*

O———○ log-periodic RBL array      ----- vertically-polarised trough aerial

## 7. References

1. MILLARD, G.H. and RILEY, J.L. 1974. A u.h.f. vertically-polarised receiving aerial for re-broadcast links. BBC Research Department Report No. 1974/8.

2. CAUSEBROOK, J.H., DAVIS, B. and SANDELL, R.S. 1969. The prediction of co-channel interference to television broadcast services in the frequency range 470 — 860 MHz. BBC Research Department Report No. 1969/33.

3. RILEY, J.L. 1973. A u.h.f. ruggedised log-periodic aerial. BBC Research Department Report No. 1973/24.

4. MILLARD, G.H. 1972. U.H.F. relay stations: distribution transformers for use with the standard horizontally-polarised R.B.L. aerial. BBC Research Department Report No. 1972/16.

